Mammal research in southern Africa: present patterns and future priorities

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We conducted a survey to identify present patterns and future priorities for mammal research in southern Africa (countries including and southwards of Angola, Zambia and Tanzania). Two sets of peer-reviewed journals were scanned for papers on southern African mammal research over the period 1988–1998: one set comprised five journals published in South Africa; the other comprised 10 journals published abroad. For the same period we reviewed titles of M.Sc. and Ph.D. dissertations completed in zoology departments of South African universities. A questionnaire was administered by e-mail to 126 researchers active in mammal research in southern Africa, concurrently with a separate questionnaire to 97 individuals and organizations representing the stakeholders in southern Africa's indigenous mammalian resources. Our literature search found that small mammals (<5 kg), which include 83% of southern Africa's mammal species, have been the subject of 40% of research publications on the region's indigenous mammals over the past decade. Researcher respondents identified conservation biology as a priority research discipline, although postgraduate training in South Africa, as indicated by dissertation titles, does not reflect this. Stakeholder respondents indicated a lack of either awareness of, or confidence in, the ability of scientific research to improve sustainable benefits to people from the region's indigenous mammalian resources. We conclude that descriptive, taxonomically defined research should be directed at southern Africa's poorly described small terrestrial mammals, as well as its marine mammals. Fundamental research on the better-described terrestrial species, which include the charismatic megafauna, will be best served by a thematic, question-driven approach that ignores taxonomic boundaries. The priority for applied research is the integration of biodiversity conservation and sustainable use, with the communication gap between researchers and stakeholder communities requiring particular attention.

Depending on the criteria used to define southern Africa, estimates of the richness of the region's terrestrial mammal fauna range from at least 226 species[1] to more than 400 species,[2] with at least 43 species of marine mammal having been recorded in the region's coastal waters.[3] There is also a rich mammalian fossil history, which includes important fragments of hominid evolution.[4] Extant species, which range from the large and charismatic to the small and furtive, include many that have received little or no serious attention from researchers. This is despite impressive achievements by some southern African mammalogists (a notable example being the late Reay Smithers[5]). Southern African mammalogists (together with all other biologists active in the region) certainly have fertile ground to work in, and mammalogy has in fact been identified as the greatest strength of South African terrestrial zoology.[6] The opportunities and constraints are, however, shifting. While local funding for salaries and research continues to shrink inexorably throughout southern Africa, the availability of international funding for research collaboration is increasing. The result is that we are under increasing pressure to tailor our research objectives to conform to the agendas of international donors, and are increasingly finding ourselves working as collaborators in international teams. This trend is good for research output when judged in terms of the quality and quantity of papers in international journals, but should not be at the expense of regional research needs or priorities. With this in mind, we have to be clear about *why* mammal research is needed in southern Africa and *what* research should be conducted.

Answering the *why* question is the less difficult one for both fundamental and applied research on our rich mammal fauna, given (a) the numerous gaps in the scientific knowledge on it and (b) the potential benefits that it offers to southern African economies. The indigenous mammals of southern Africa constitute a resource that is becoming increasingly recognized for the two main sets of benefits it offers. The first set comprises direct economic benefits, which can be realized across scales ranging from rural households to national treasuries. These may be derived through various forms of resource use, both consumptive (hunting for meat, trophies, ivory, hides, game capture for live-sales, etc.) and nonconsumptive (mainly tourism). The second set comprises ecological benefits. These are realized through the multitude of proximate interactions between mammals and other taxa (herbivory, predation, etc.) and the ultimate influences they have as mediators of ecosystem processes (nutrient cycling, seed dispersal, pollination, plant community succession, etc.).[7] Ecological benefits translate into indirect economic benefits because indigenous mammals, having coevolved with all other indigenous taxa, are integral components of all the various ecosystems that provide goods and services (water, food, energy, etc.)[8] to southern African people.

Advancing scientific knowledge about our own mammalian resources, and improving our applied understanding of how to sustain the benefits they provide us with are, we argue, compelling reasons *why* southern Africa needs to maintain an endogenous capacity for mammal research of an international standard. An answer to the question of *what* mammal research is needed is, however, much more elusive and transient. We nevertheless take up the challenge in this paper by reporting on a survey we conducted recently. This involved reviewing trends in mammal research in southern Africa over the past decade and soliciting opinions from scientists and stakeholders as regards directions for future research. Our aim is to stimulate discussion on how mammal research in southern Africa should progress in the arena of international funding and collaboration, while maintaining a focus that is regionally relevant and responsive to stakeholder interests.

The surveys

We defined southern Africa as the region covered by the countries on the continent of Africa that constitute the Southern African Development Community (SADC), with the exclusion of the Democratic Republic of Congo. This definition is somewhat arbitrary (as are all other definitions used) but we justify it in two ways. First, it was convenient to use country boundaries for the sake of our literature survey. Second, the countries included either straddle or lie south of the South Equatorial Divide (SED), which has been suggested as a line of division with some biological relevance.[9] The SED can be roughly drawn on a map as a line running through the Bie' Plateau (Angola) in

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the West and Mount Kilimanjaro (Tanzania) in the East, following for much of its extent the watershed between the Zambezi and Congo basins. We defined southern African marine mammal research as that which is conducted from operational bases located within southern Africa.

To identify past trends in mammal research in southern Africa, we conducted a literature search covering the period 1988–1998. We searched two sets of peer-reviewed scientific journals for articles based on research conducted in southern Africa on mammals indigenous to the region: those published in South Africa and a selection of those published abroad. The South African journals were *South African Journal of Science, South African Journal of Zoology, South African Journal of Wildlife Research, South African Journal of Antarctic Research* and *South African Journal of Marine Science*. The international journals were *Conservation Biology, Journal of Zoology (London), Behaviour, African Journal of Ecology, Journal of Tropical Ecology, Journal of Arid Environments, Journal of Mammalogy, Mammalia, Marine Mammal Science* and *Marine Biology*. We excluded articles with a veterinary or agricultural focus. We also scanned the titles of all M.Sc. and Ph.D. dissertations[10] completed in the zoology departments of South African universities during the period 1988–1998. For each set of journal articles we calculated for each year the percentage that were based on research on southern African mammals. Of these, we then calculated percentage breakdowns by mammal grouping and research discipline. Mammal groupings were: small mammals (<5 kg); large herbivores; large carnivores; marine mammals. Research disciplines were: ecology (including nutrition); conservation (including utilization); behaviour; physiology (including reproduction and growth); population dynamics; taxonomy, genetics, anatomy and evolution (grouped); techniques; 'other'. The same breakdowns were calculated for M.Sc. and Ph.D. dissertations.

We conducted a questionnaire survey of professional scientists (that is, employed as such) with postgraduate qualifications who are active in mammal-orientated research in southern Africa. These included some scientists based at overseas institutions. The questionnaire (Appendix 1) was administered by e-mail and was sent to 126 researchers. A second e-mail questionnaire survey was conducted among stakeholders in southern Africa's mammalian resources (Appendix 2). We considered stakeholders to include: the interested public represented by wildlife societies; national and provincial parks and wildlife agencies; commercial wildlife producers; safari and tour operators; rural communities represented by local development agencies; conservation NGOs; international aid agencies. This questionnaire was sent to 97 e-mail addresses. The two questionnaires were sent out concurrently. After six weeks a reminder message was sent to all who had not responded and data collection was terminated one week later.

Both questionnaires were made as simple and brief as possible to maximize respondent sample sizes and were designed for ranked responses to facilitate data analysis. When respondents allocated the same rank to two or more categories, we applied the tied ranks procedure as used in the statistical treatment of ranked data.[11] A measure of importance of each category in each questionnaire was derived either as the mean rank awarded (averaged across all respondents), or as the percentage frequency with which respondents ranked that category in the top third of all possible ranks.

Results

In the selected international journals, 3.7% of all articles published over the past decade (n = 10 619) were concerned in some way with southern African mammals, while among the South African journals the figure was 10.7% (n = 3105). Of all articles concerned with southern African mammals during this period, 42.9% of international journal articles and 90.3% of South African journal articles were based on research conducted in South Africa. The bulk of southern African mammal research over the past decade, as quantified in terms of journal publications and postgraduate dissertations, was directed at small mammals and large herbivores (Fig. 1). We compared (by the χ^2 test) the frequency distribution of research articles (in international and South African journals combined) published over the past decade on southern African terrestrial small mammals, large herbivores and large carnivores, with the frequency distribution of species in these groupings. Using Bigalke's list[2] of 338 small mammals (<5 kg), 55 large herbivores and 12 large carnivores, we found the frequency distributions to be significantly different ($P < 0.001$), with small mammals being under-represented in the literature (83% of species but 40% of research articles). The breakdown of journal articles by mammal groupings showed no distinct trends over the period under review in either international or South African journals, although a trend was detected among South African postgraduate dissertations (Fig. 2). Small mammal topics dominated postgraduate mammal research in the late 1980s and early 1990s, but since about 1993 there has become an increasingly even distribution of postgraduate research across mammal groups. There has also been an increase in the annual output of mammal-orientated dissertations in South Africa, with a decrease in the amplitude of variation in output between years. Of all the dissertations (n = 114) completed on mammal research in the zoology departments of South African universities since 1988, the University of Pretoria dominated with 40%, followed by the University of Natal (25%, Durban and Pietermaritzburg campuses combined) and the University of the Witwatersrand (8%).

With regard to the disciplines within which mammal research has been conducted over the past decade in southern

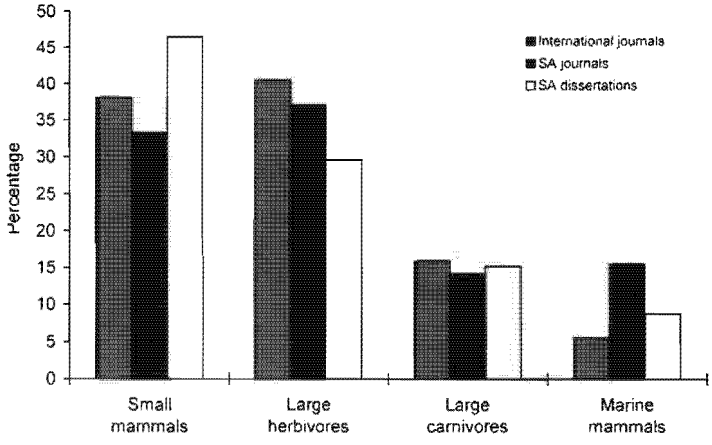

Fig. 1. Percentage breakdown by broad mammal grouping of research papers on southern African mammals in journals published internationally (389 papers) and in South Africa (331 papers), and of South African postgraduate dissertations (114), during the period 1988–98.

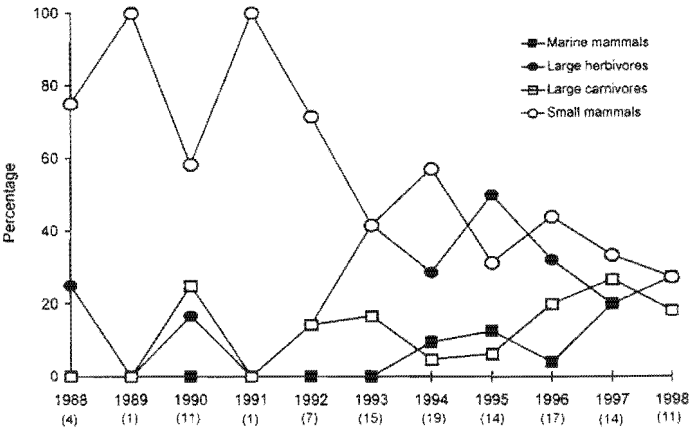

Fig. 2. Yearly percentage breakdown by broad mammal grouping of postgraduate (M.Sc. and Ph.D.) dissertations[10] completed in zoology departments of South African universities over the period 1988–98. Numbers in brackets indicate the number of dissertations completed per year.

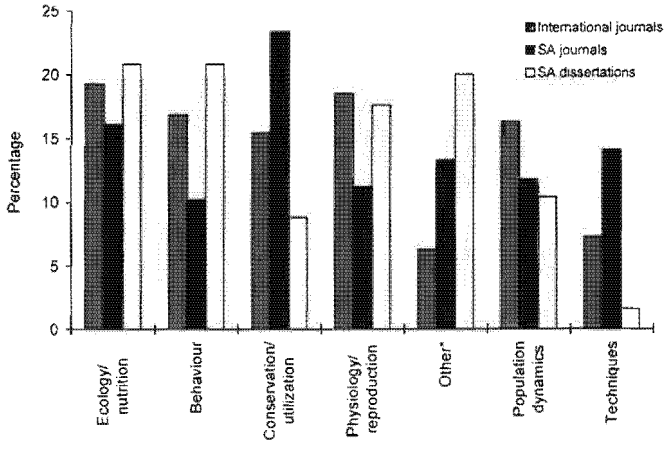

Fig. 3. Percentage breakdown by research discipline of journal publications and South African dissertations on southern African mammals during the period 1988–98, using the same database as for Fig. 1.*The group 'other' refers to anatomy, taxonomy, genetics and evolution.

Africa, articles with a conservation focus (Fig. 3) occurred with the highest frequency in South African journals. Surprisingly, this was in sharp contrast to the South African postgraduate dissertations, among which conservation topics were poorly represented. The articles in international journals were more evenly spread across disciplines, with ecological and physiological topics being the most common.

The questionnaire to researchers (Appendix 1) achieved 75 responses to Section A and 79 to Section B (Table 1). Among mammal groups considered by respondents to be in most need of further research in southern Africa, small mammals clearly emerged as most important, followed by large herbivores (Fig. 4). This reflects the pattern emerging from the past decade's publications and dissertations (Fig. 1). Furthermore, out of 17 responses that identified various 'other' mammalian groupings in need of further research, bats formed a distinct group followed by small carnivores (seven and five responses, respectively). Among research disciplines, respondents identified the group including biodiversity conservation, ecology, sustainable use and population biology as having distinctly greater needs than all the others (Fig. 5). We compared mean ranks awarded to research disciplines by respondents with the percentage breakdown of articles in South African and international journals over the past decade (Fig. 6). This revealed some overall conformities, in that the disciplines ranked highly by researchers generally produced the most publications (especially conservation and ecology) in both South African and international journals.

The questionnaire to stakeholders achieved 40 complete responses (Table 1). Stakeholders identified the conservation of biodiversity as the most important topic for further input from mammal research in southern Africa (Fig. 7). Research on endangered species and human/wildlife conflict followed thereafter. Interestingly, stakeholders considered research support to the communal and private wildlife sectors (community-based wildlife management, game ranching, hunting and photographic tourism) to be of less importance than to the scientific and public sectors (fundamental research and management of state and provincial parks).

Table 1. Numbers of responses received to questionnaires sent to mammal-orientated researchers (n = 126) and stakeholders (n = 97) with interests in southern Africa's indigenous mammal fauna, broken down into responses received from South Africa, the southern African region (excluding South Africa) and overseas (Australia, Europe and U.S.A.).

Respondent base	Researchers	Stakeholders	Total
South African	57	25	82
Regional	7	13	20
Overseas	15	2	17
Total	79	40	119

Discussion

We recognize that the selection of international journals for our literature search could have influenced the breakdown of articles by mammal grouping and research discipline. Nevertheless, the distributions of articles across mammal groupings in international and South African journals were not dissimilar (Fig. 1). Also, the conformity between the mean ranks awarded to disciplines by researchers, and the relative frequencies with which those disciplines appeared in international journals (Fig. 6), confirms that our selection was not inappropriate. Factors that could have influenced our questionnaire results include the choice of respondents and the response percentage achieved. Because our questionnaires were administered electronically, we restricted our respondent population to people with functional e-mail links, which might have affected the stakeholder survey to some extent. The overall response we achieved (Table 1) was nevertheless gratifying and is probably attributable largely to the convenience of e-mail correspondence. This is indicated by the 63% response we received by e-mail from mammal-orientated researchers compared to the 34% response

Chown and McGeoch[6] received by post from terrestrial zoologists.

Our literature survey confirmed that published research on southern African mammals is strongly skewed towards work conducted within the borders of South Africa, which is to be expected from the distribution of mammal researchers that responded to our questionnaire (Table 1). This immediately highlights the need for more South African scientists to explore research opportunities across national boundaries, and for international development agencies to fully appreciate the opportunities for technology transfer between South Africa and other countries in the region. The unavoidable fact remains that the results presented here have an obvious South African bias.

Considering the question of *what* mammal research is needed in the foreseeable future in southern Africa, we propose that our survey results provide at least three useful pointers. First, small mammals emerged as the group that is most in need of further attention from researchers (Fig. 4). This is despite the fact that dissertations on small mammals have dominated postgraduate research in South Africa over the past decade, during which time small mammal research has also generated a relatively high proportion of the region's output of journal publications (Fig. 1). In relation to the number of species, however, the research outputs on southern African small mammals have actually been relatively low. This is not unexpected given that in all continental or subcontinental species assemblages there are many more small mammals (and other organisms) than there are large ones,[12] while field research on small mammals is generally more difficult in terms of methods and funding than it is on large mammals.

Secondly, conservation biology predictably emerged as the discipline in which mammal research is most deserving of continued efforts in southern Africa (Fig. 5) but postgraduate research, as reflected by South African dissertation topics (Fig. 3), has not responded to this need over the past decade. This discrepancy no doubt reflects the dilemma of the cautious academic supervisor. It is safest to direct students towards mainstream scientific projects that are likely to generate statistically significant results within a prescribed period, while most potential projects arising from conservation problems are inherently unpredictable in outcome. University academics clearly have to become more adventurous and creative in stimulating postgraduate studies in mammalian conservation biology.

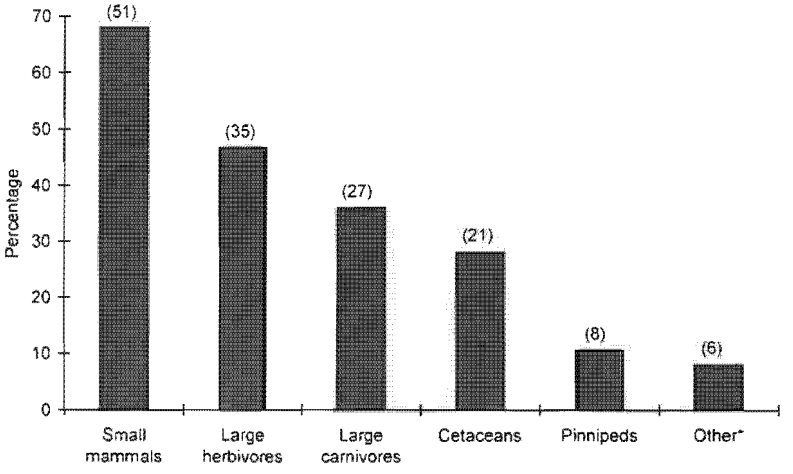

Fig. 4. Percentage frequency distribution of responses to the researcher questionnaire (Appendix 1, Section A) that ranked particular mammal groupings highly (first or second out of six) in terms of their further needs for research in southern Africa. Numbers in brackets indicate the number of times (out of 75 responses) a mammal grouping was highly ranked.*The group 'other' refers to various other mammal groupings individually defined by respondents.

Thirdly, our results suggest that mammal research is not perceived to be of much direct benefit to people and institutions that are stakeholders in southern Africa's indigenous mammals. Research to support the sustainable generation of material and financial benefits from this resource (for instance, through community-based wildlife management, game ranching and the tourism industry) was given lower priority by stakeholder respondents than more fundamental research directed at the conservation of biodiversity and endangered species, for example (Fig. 7). Researchers, on the other hand, placed a high priority on sustainable use as a topic for further research (Fig. 5). This discrepancy could reflect a lag in public awareness as the 'use it or lose it' principle[13] is still gaining acceptance among conservation biologists. Alternatively, it could reflect the widespread lack of faith in the ability of scientific research to make a meaningful contribution to sustainable development in Africa, following its generally unimpressive contributions to date.[6,14] Either way, the challenge is on for mammal-orientated researchers in southern Africa[15] (and all other researchers with interests in Africa's indigenous biotas[16]) to find more effective ways of bridging the information gap that presently separates scientists from user communities and other stakeholders. For scientists in the Third World this challenge is particularly difficult to meet. We strive to produce research results of an international standard and to demonstrate this we publish

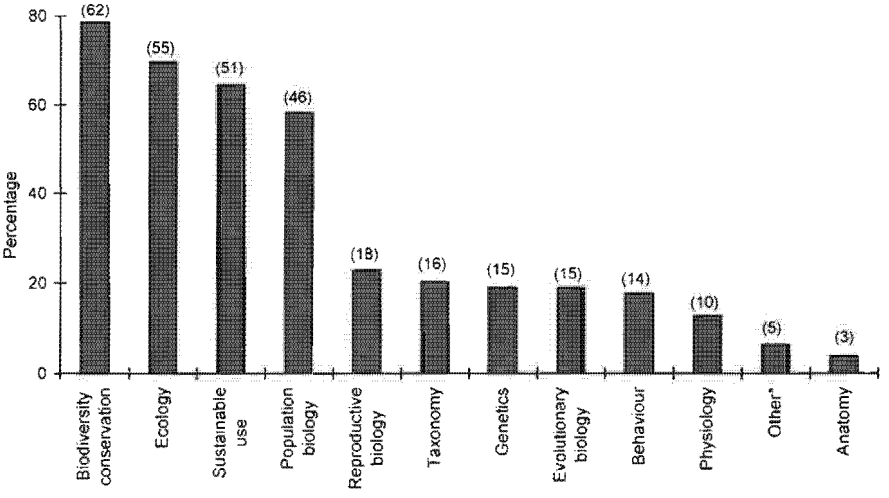

Fig. 5. Percentage frequency distribution of responses to the researcher questionnaire (Appendix 1, Section B) that ranked particular research disciplines highly (first to fourth out of 12) in terms of their further importance to research on southern African mammals. Numbers in brackets indicate the number of times (out of 79 responses) a research discipline was highly ranked.*The group 'other' refers to other research disciplines individually defined by respondents.

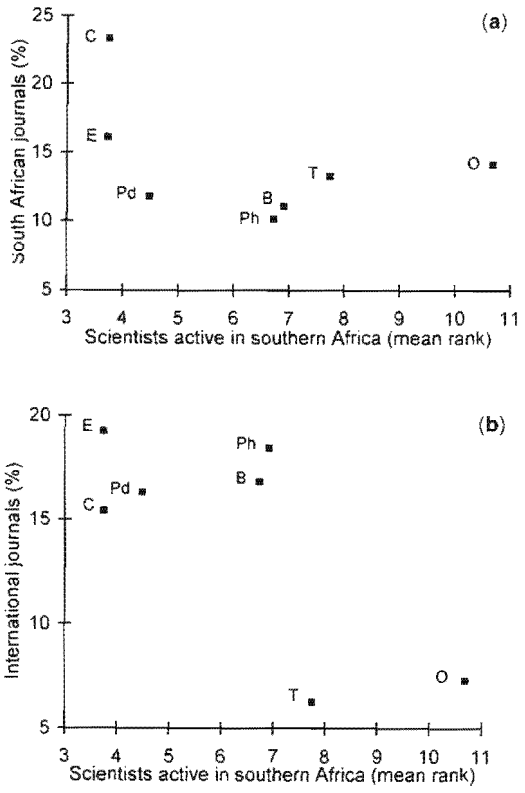

Fig. 6. Percentage occurrence of research disciplines among publications on southern African mammals in (**a**) South African and (**b**) international journals during 1988–98, plotted against mean ranks of importance (1 highest, 11 lowest) awarded to those disciplines by researcher respondents (Appendix 1, Section B). Symbols: C, conservation (including utilization); E, ecology (including nutrition); Pd, population dynamics; Ph, physiology (including reproduction and growth); B, behaviour; T, techniques; O, other (including anatomy, taxonomy, genetics and evolution).

our best results in international journals, which are too expensive for most Third World libraries to subscribe to. Evaluation criteria used by the National Research Foundation[17] (the government funding body for scientific research in South Africa) inevitably entrench this practice by awarding higher weightings to research outputs published in international journals than those published locally. Research to support sustainability in the use of indigenous mammals is clearly needed throughout Africa,[15,18] but local researchers who wish to be more effective in this arena will have to brave professional risks and be innovative in making their results accessible and relevant to local users.[16] An obvious option is for local researchers to summarize their findings in popular local publications while publishing the definitive versions in international journals, despite the added time costs involved.

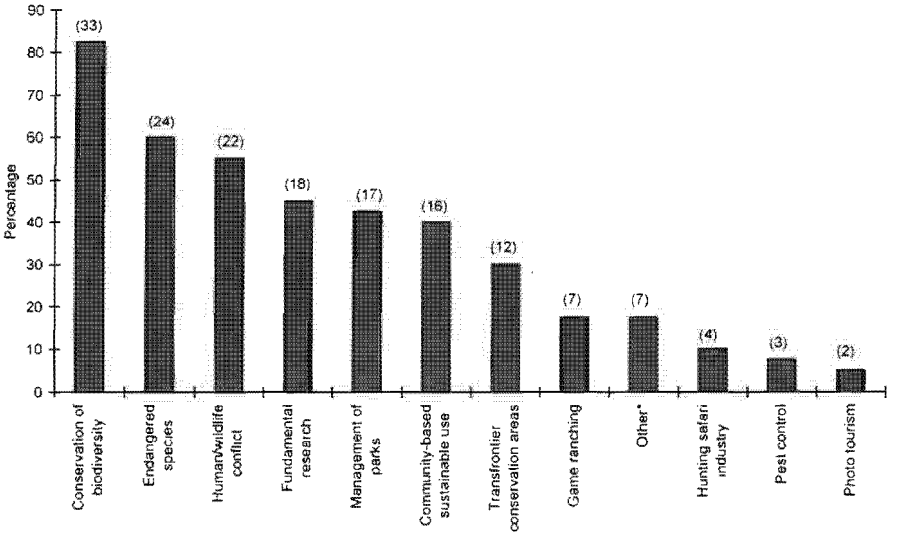

Fig. 7. Percentage frequency distribution of responses to the stakeholder questionnaire (Appendix 2) that ranked particular topics highly (first to fourth out of 12) in terms of their needs for further input from mammal research in southern Africa. Numbers in brackets indicate the number of times (out of 40 responses) a topic was highly ranked.

Our interpretation of the questionnaire results so far is based on the analysis of ranked data returned by respondents who followed the format we provided. Valuable contributions were also made, however, by a further eight respondents (all researchers, not unexpectedly), who disregarded the questionnaire and replied with written comments instead. The prevailing theme in these comments was the rejection of the taxonomic limits implied by our questionnaire. The alternative view is that greater scientific value is to be derived by avoiding a focus on any particular mammal group and instead adopting a thematic, question-driven approach to research that cuts across taxonomic boundaries. The approach is to identify an interesting research question first and then find an appropriate species (or range of species) that can be studied to generate results, which may contribute more to answering the research question than advancing knowledge on the study species or its taxonomic group. For example, in the field of social biology the question of how a dominant individual monopolizes reproduction is a focus of ongoing research in South Africa on mole-rats (Bathyergidae, Rodentia; see Bennett *et al.*[19]). Results of this research could be more relevant to other studies directed at the same question but involving species from another order, such as the Carnivora[20–22] (or even another phylum, in the case of social insects[23]), than to most other studies on rodents. We are entirely sympathetic with this approach and the reason we structured our researcher questionnaire (Appendix 1) the way we did was not because we prefer a taxonomically orientated approach to biological research. It was first, because the list of potential research questions would be endless; second, because we wanted to compare our questionnaire results with those from our literature survey, and finally, because we recognized a traditional taxonomic structure within our respondent population. Some research institutions (e.g., the Mammal Research Institute) and most posts in biology departments of universities,

museums and government research institutions in southern Africa are described in terms of a taxonomic grouping (small mammal biologist, marine mammal biologist, curator of mammals, carnivore specialist, etc.).

Our researcher questionnaire served to test the level of adherence to the view that mammal research is partitioned along taxonomic or functional divisions within the fauna. Among our respondents a strong lobby drew attention to a requirement for further descriptive research on small mammals with particular emphasis on bats, insectivores and small carnivores (viverrids and mustelids). Marine mammal research forms a category of its own, largely due to the methodological distinctions that separate marine and terrestrial research. For the rest, however, it appears that research on southern Africa's mammal fauna will best be served by a thematic, question-driven approach that ignores taxonomic boundaries. Fundamental research should particularly address questions about ecological and evolutionary processes across spatial and temporal scales,[24,25] and should include some long-term studies at well-monitored sites. Applied research should address questions of direct relevance to regional needs[15] and research planning should take cognizance of the end-users of research results. In particular our survey results indicate a continuing need for questions involving the integration of biodiversity conservation and sustainable use to be addressed within the continuum between fundamental and applied research. This requires productive and committed southern African researchers constantly to balance the individual and institutional benefits of collaborating with researchers overseas against the regional benefits of collaborating with those in neighbouring countries. It also requires a commitment to bridging the communication gap by finding effective ways of making research results accessible and useful to stakeholder communities.[6,16]

We are grateful to the Department of Research Support at the University of Pretoria for funding this project. A. van Jaarsveld, N. Bennett and two anonymous referees are thanked for their constructive comments on earlier drafts of the manuscript.

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Appendix 1

Questionnaire administered by e-mail to 126 professional scientists engaged in research on southern African mammals.

Section A

Please rank in order of importance (1 being most important, insert value in brackets) the following broad mammalian groupings in terms of their needs for further research in southern Africa (research 'needs' may apply to advancing scientific knowledge, conservation status, economic returns, etc.):

Terrestrial mammals, small ( )
Terrestrial mammals, large, herbivores ( )
Terrestrial mammals, large, carnivores ( )
Marine mammals, cetaceans ( )
Marine mammals, pinnipeds ( )
Any other mammalian grouping you wish to define — please state ( )

Section B

Please rank in order of importance (1 being most important) the following disciplines, which are obviously not mutually exclusive, in terms of their applications to the mammalian groupings to which you have given priority rankings above:

Biodiversity conservation ( )
Sustainable use ( )
Ecology ( )
Physiology ( )
Reproductive biology ( )
Population biology ( )
Taxonomy ( )
Genetics ( )
Anatomy ( )
Behaviour ( )
Evolutionary biology ( )
Any other discipline you wish to define — please state ( )

Appendix 2

Questionnaire administered by e-mail to 97 individuals or organizations considered to be stakeholders in southern Africa's indigenous mammalian resources (wildlife societies, national and provincial parks and wildlife agencies, commercial wildlife producers, safari and tour operators, rural communities represented by local development agencies, conservation NGOs, international aid agencies, etc.).

Please rank the following topics (1 being most important, insert value in brackets), which are not all mutually exclusive and are listed in random order, in terms of their needs for further inputs from mammal research in southern Africa:

Resolution of human/wildlife conflict ( )
Management of transfrontier conservation areas ( )
Protection of endangered species ( )
The hunting safari industry ( )
Fundamental research to advance scientific knowledge ( )
Community-based use of indigenous mammalian resources ( )
Conservation of biodiversity ( )
Game ranching ( )
The photographic tourism industry ( )
Pest control ( )
Management of national or provincial parks ( )
Any other topic you wish to define — please state ( )